

Health Consultation

GLEN DALE TCE SITE

603 BALTIMORE AVENUE

GLEN DALE, MARSHALL COUNTY, WEST VIRGINIA 26038

EPA FACILITY ID: WVSN0305381

OCTOBER 29, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Prepared By:

West Virginia Department of Health and Human
Resources
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Foreword

This document summarizes retrospective public health concerns for the Glen Dale TCE site. These public health concerns were related to the detection of trichloroethylene (TCE) from 1992 to 1999 in the city's municipal drinking water well, located immediately south of the site in concentrations ranging from non-detection to 81 micrograms per liter ($\mu\text{g/L}$) or parts per billion (ppb). At the request of West Virginia Department of Environmental Protection (WVDEP), the West Virginia Department of Health and Human Resources (WVDHHR) prepared this public health consultation to determine the public health significance from potential exposure related to sub-surface soil and groundwater trichloroethylene (TCE) contamination to Glen Dale residents and current workers at the former manufacturing building. WVDHHR prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

The steps taken in completing a health consultation are as follows:

Evaluating exposure: The WVDHHR-ATSDR Cooperative Partners Program starts evaluating community exposure pathways by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it's located, and how people might be exposed. WVDHHR does not collect environmental samples, but relies on information provided by the West Virginia Department of Environmental Protection (WVDEP), EPA, and other sources that followed specific procedures to ensure the collection of accurate, and reliable information.

Evaluating health effects: If evidence indicates that people are, have been, or could be exposed to hazardous substances, WVDHHR will take steps to evaluate whether that exposure could be harmful.

Developing recommendations: In the health consultation, WVDHHR outlines its conclusions regarding potential health threat posed by site-related chemical exposure and provides recommendations for reducing or eliminating human exposure. The role of WVDHHR at a site is primarily advisory. Therefore, the recommendations in the health consultation will be communicated to and acted on by other agencies, such as WVDEP and EPA.

Soliciting community input: This evaluation process is interactive with all stakeholders. WVDHHR starts by soliciting and evaluating information from various governmental agencies, property owners and those responsible for cleaning up contamination, and community members surrounding the site. Any conclusions about the site are shared with the community and groups that provided information.

If you have questions or comments about this report, we encourage you to:

Write: ATSDR Cooperative Partners Program
 Office of Environmental Health Services
 Bureau for Public Health
 West Virginia Department of Health and Human Services
 Capitol and Washington Streets, 1 Davis Square, Suite 200
 Charleston, West Virginia 25301-1798

or call: (304) 558-2981

Summary and Statement of Issues

At the request of West Virginia Department of Environmental Protection (WVDEP), the West Virginia Department of Health and Human Resources (WVDHHR) prepared this public health consultation to determine the public health significance from chemical exposure related to subsurface soil and groundwater trichloroethylene (TCE) contamination to Glen Dale residents and current workers at the former manufacturing building. The US Environmental Protection Agency (USEPA) and WVDEP have conducted environmental investigations and assessment activities at the site since 1998. For this health consultation, WVDHHR reviewed the available public drinking water TCE data from 1991 to 2002 from Glen Dale Water Works and soil, soil gas, and groundwater data collected by the contractor for EPA in December 1998. TCE was not detected prior to 1992 and after 1999 a treatment system was installed to remove TCE from the Glen Dale public water supply. We specifically evaluated potential TCE exposures related to the TCE contamination found in the Glen Dale public drinking water from 1992 to 1999.

The primary routes of human exposure to chemicals from the Glen Dale TCE site were through the public water system (drinking the water, inhalation and dermal absorption during showering). Based on the environmental data review, site-specific exposure dose estimations (total exposure from drinking, breathing and skin contacting during showering) and toxicological analyses, WVDHHR concluded that:

1. The eight (8) years of documented TCE exposure (1992-1999) via the Glen Dale public drinking water supply poses no apparent public health hazard to community members, including children. Non-cancer health effects are not expected because estimated exposure levels were below levels known to cause effects in humans and animals.
2. The eight (8) years of documented TCE exposure (1992-1999) via the Glen Dale public drinking water supply poses no apparent carcinogenic health hazard to community members, including children. WVDHHR estimated theoretical cancer risk from TCE exposure (1992-1999) is less than one additional case of cancer in 10,000 people, which is considered a very low risk by WVDHHR. The current cancer rate in the U.S. population is between 30 - 50% i.e., approximately one in three women and one in two men will develop cancer during their lifetime (for additional information go to <http://seer.cancer.gov/statfacts/html/all.html>).
3. It is unlikely workers at the North and South Buildings and/or residents were exposed to unsafe levels (if any) of TCE through vapor intrusion.

The WVDHHR prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

Site Description and History

The Glen Dale TCE site is located at 603 Baltimore Avenue, Glen Dale, Marshall County, West Virginia, along the east bank of the Ohio River. The site location and topographic setting are illustrated by Figure 1 in Appendix C.

The site is in a mixed residential and small-scale commercial/industrial area. It is situated between Baltimore Avenue on the east and an operating grass air field on the west. The Ohio River is approximately 200 yards to the west of the site. Residential properties are north, south and with the vast majority to the east.

The old manufacturing facility on the site consists of two large, long buildings referred to as “North” and “South”. The North building was originally owned and operated by the Fokker Aircraft Company until the 1930’s. Then Marx Toy Corporation used the North building, and later built South building, to manufacture toys until the early 1980’s. According to the city water department, TCE was used for various industrial purposes at the Marx Toy Corporation. In June 1986, Wheeling Wholesale Grocery Company acquired the North Building from the Ohio Valley Industrial & Business Development Corporation and operated the facility as a warehouse for non-perishable food until the mid-1990’s [1]. The current owner is Warren Distribution, Inc., a manufacturer and wholesale distributor of automotive aftermarket products. The South Building was purchased by United Industrial Realty Company and currently houses a small machine shop, Glen-X Machine.

A 98-foot deep [2] municipal primary drinking water supply well (Well #1) is located 2,500 feet and 1,000 feet south of the North and South Buildings, respectively, and supplies raw water to the Glen Dale Water Works. Water is pumped from Well #1 where chemicals, including chlorine and fluoride are added into the waterline at the pump house. The disinfected and fluoride-treated water then flows into the distribution system [3]. According to EPA’s rules, water samples were collected from the system immediately following the treatment point.

Starting January 9, 1989, EPA required TCE to be regulated across the U.S., the minimal sampling frequency is once every three years. Available site information indicates that the first time Glen Dale Water Works tested for TCE was July 1991, and TCE was not detected. In the next sampling event (April 1992), TCE was detected at a concentration of 72 ppb, which exceeds EPA’s Maximum Contaminant Level (MCL) of 5 ppb. From April 1992 through March 1999, TCE was detected intermittently at concentrations ranging from non-detection to 81 ppb. The newest well (Well #2) located approximately 250 feet south of Well #1 was finished as a backup well in early 1999, and reportedly TCE has never been detected in the new well. Two older industrial wells located southeast of the South Building were in service until 1988 (Sean Orlofske, Glen Dale Water Works, personal communication, June 2007). There are no known users of private well water in the immediate vicinity of the site [1].

According to a historical blueprint of the former Marx Toy Company, two possible sources of contamination were identified [4]:

1. a 550-gallon underground storage tank (UST) containing TCE on the west side of the North Building, and
2. a former paint-gun cleaning station on the west side of the South Building.

In December 1998, a contractor for EPA conducted a removal assessment and collected soil gas, soil and groundwater samples at the identified locations. The soil gas TCE level at 4 feet below ground surface (bgs) was up to 6,130 parts per billion by volume (ppbv) in the vicinity of the suspected UST, and at 8 feet bgs was as high as 810 ppbv near the paint gun washing station. Another sampling location between the North and South Buildings (on the west side) had the maximum TCE level of 10,720 ppbv in the soil gas at 4 feet bgs. Soil and groundwater samples

were collected based on the soil gas sampling results. The highest concentration was 980 ppb in the soil samples and 3,500 ppb in the groundwater samples, both of which were near the suspected UST area. The groundwater sample taken near the municipal water well contained 16 ppb TCE [5].

In late March 1999, a new water treatment plant with an air stripper was completed and put in service. All raw water pumped by the Glen Dale Water Works is treated by air stripping and disinfected prior to distribution (Sean Orlofske, Glen Dale Water Works, personal communication, June 2007). The air stripper effectively removed the TCE from the raw water, and there has not been a TCE violation (i.e., nothing above the MCL of 5 ppb) since April 1999.

Demographics

Based on the 2000 census, the population of Glen Dale, West Virginia was 1,552 people. In the city, the population was about 19.3% under the age of 18, 5.9% from 18 to 24, 23% from 25 to 44, 28.1% from 45 to 64, and 23.7% were 65 years of age or older [6]. Two (2) schools are located within city limits of Glen Dale: Glen Dale elementary school operates K-6th grades with current enrollment of 205 [7], and John Marshall high school operates 9th – 12th grades with a total of 1,399 students [8]. Sherrard Jr High School in Wheeling WV serves 7-8th grade Glen Dale students. The elementary school is approximately a half mile east of the site. According to the City's water department, the municipal water system serves approximately 1,100 people in the area.

Trichloroethylene (TCE)

TCE is a clear, odorless, nonflammable liquid used for degreasing fabricated metal parts. Consumer products that contain TCE include typewriter correction fluid, paint removers and strippers, cosmetics, rug cleaners and spot removers and adhesives. Before 1997, TCE was used as a general anesthetic, analgesic, grain fumigant, disinfectant, pet food additive and extractant of spices and caffeine in coffee (ATSDR 1997).

TCE is about 1.5 times heavier than water and not very soluble in water. TCE is commonly found as vapor in air as it readily evaporates. It adheres to particles in water and soil, tends to settle to the bottom sediment, and remains in soil for a long time [9].

People could be exposed to TCE in groundwater by drinking TCE contaminated water, breathing TCE while taking a shower or during other indoor and outdoor activities, and/or absorbing TCE through the skin when in contact with contaminated water. It can also be inhaled from indoor air if TCE in groundwater moves through soil and into the building or house above.

People who are exposed to large amounts of TCE can become dizzy or sleepy and may become unconscious at very high levels. People who breathe moderate levels of TCE may have headaches or dizziness. Animals that were exposed to moderate levels of TCE had enlarged livers, and high-level exposure caused liver and kidney damage. Animal studies have reported that high levels of TCE cause cancer and can effect many organ systems including the liver and kidney. The levels at which these effects occur in humans are not well characterized. It is uncertain whether people who breathe air or drink water containing TCE are at higher risk of cancer, or of having reproductive effects (ATSDR 1997). TCE has been classified by the National Toxicology Program (NTP) as "reasonably anticipated to be a human carcinogen", the International Agency for Research on Cancer (IARC) as "probably carcinogenic to human" , and

USEPA as “probable human carcinogen due to insufficient human but adequate animal studies [9].

Historical Investigation and Site Activities

Table 1. Summary, Environmental Investigation History for the Glen Dale TCE Site	
Date	Event/Action
September 1998	EPA was notified of the TCE detection in Glen Dale Municipal water
December 1998	EPA conducted a removal assessment by collecting multi-media samples
February 1999	EPA determined the TCE release from the site endangered public health
April 1999	EPA approved funding to undertake a removal action at the site
August 1999	EPA sampled soil and groundwater and found low levels of TCE throughout the property. EPA entered into an Administrative Order by Consent (AOC) on August 4, 1999 [10]
March 2000	EPA personnel witnessed earth-moving activities at the site in the vicinity of a suspected buried TCE tank; the removal of a 30,000 gallon above ground propane storage tank and an 8,000 gallon above ground triad tank (which reportedly was used for the storage of TCE). The tanks were cut up on-site, removed and salvaged for scrap [10].
September 2000	EPA’s Unilateral Administrative Order (UAO) required more sampling activities to allow EPA to assess the degree of TCE dispersion caused by earth-moving activities
August 2001	No USTs were found and sampling required by UAO showed low levels of TCE but all below the action level of 10 ppm (Suzanne M. Parent; Patricia M. Corbett , Settlement Decision Analysis, Glen Dale TCE Superfund Site, Glen Dale, Marshall County, West Virginia)

Discussion

WVDHHR determines site-specific public health significance and provides recommendations based on levels of environmental contaminants detected at the site, an evaluation of potential exposure pathways, and duration of exposure.

WVDHHR identifies contaminants for their potential to cause adverse health effects using chemical-specific, health-based comparison values (CVs) derived by various state and federal government agencies. Although concentrations at or below the relevant CVs for a given contaminant might reasonably be considered safe, concentrations above CVs will not necessarily cause harm. Rather, it does represent a point at which further evaluation is warranted. WVDHHR

uses site-specific exposure scenarios and performs in-depth evaluations for contaminants detected at concentrations above CVs.

The following CVs were used in this health consultation:

1. EPA's maximum contaminant levels (MCLs), which are determined, based on the lifetime health advisory, are the best estimates for protecting human health. MCLs provide a sufficient margin of safety.
2. EPA's reference dose (RFD), which is an estimate of the amount of a contaminant that an individual can be exposed to daily without expected adverse health effects over a lifetime.
3. Cancer slope factor (CSF), is chemical specific, and is an upper bound estimate, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to a chemical. EPA has set the acceptable risk range for cancer induction from exposure to a chemical at 10^{-4} to 10^{-6} , or one cancer per 10,000 to 1,000,000 people exposed.

Methodology

The methodology used in this health consultation is as follows:

1. Review data and select the chemical of concern
 - a. Review the available environmental sampling information and data, screen the environmental contaminant using chemical-specific, health-based environmental media guideline comparison values (CVs)
 - b. Select the contaminant of concern and associated pathways for further review when the contaminant level exceeds the screening value (environmental guideline CVs)
2. Conduct exposure analysis and further review the chemical of concern
 - a. Identify human exposure pathways
 - b. Estimate site-specific exposure doses for the contaminant that exceed the environmental CVs in completed pathways
 - c. Further screen the contaminant by comparing estimated exposure doses with health guideline CVs
 - d. Evaluate health effects of contaminant if the estimated site-specific exposure dose exceeds the health-based guideline CVs
3. Perform in-depth toxicological evaluation
 - a. Using site-specific exposure scenarios, perform in-depth toxicological evaluation for the contaminant with exposure doses above the health CVs for its potential adverse health effect
 - b. Provide appropriate site-specific recommendations as necessary

Environmental Data Review and Screening

Conclusions in this report are affected by the availability and reliability of information reviewed. WVDHHR assumes all the data points were collected and analyzed following EPA –approved sampling and analytical methods and undergone full data validation procedure.

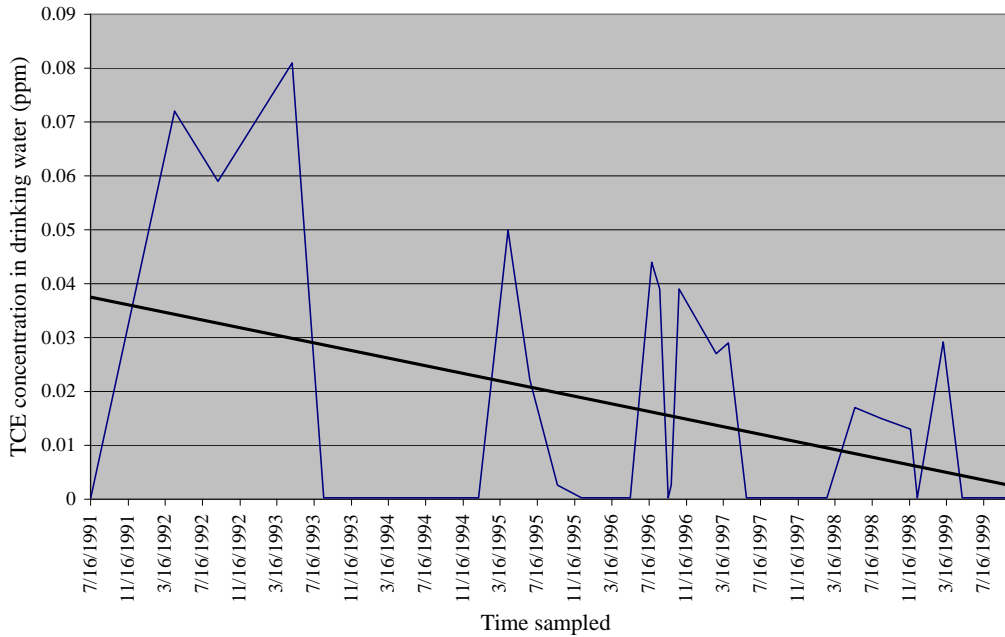
Drinking Water Data

A total of 40 drinking water TCE data points collected from July 1991 to March 2002 [11] (see Table 2 in Appendix B) were reviewed, of which 31 data points were collected before late March 1999 (i.e., prior to completion of the new water treatment system with an air stripper and new back up well). Three (3) of the 31 data points were discarded due to exceeding sample holding periods and an unusual sampling location. Of the 28 drinking water TCE data points collected between July 1991 and March 1999, 16 were found to contain TCE above the MCL, with concentrations ranging from 13 to 81 ppb, two contained TCE below the MCL, and 10 had no TCE detected in samples. The highest TCE concentration (81 ppb) was found in the water sample collected in May 1993. The first time TCE was detected above the MCL occurred in April 1992 with a concentration of 72 ppb. The last detection of TCE above the MCL was in March 5, 1999 (before the air stripper was brought on line) with a concentration of 29.2 ppb [11]. The arithmetic average concentration of TCE during the period from April 1992 to March 1999 is 18.8 ppb (see Table 3), which exceeds the MCL of 5 ppb.

Table 3. TCE Levels in Drinking Water from 1992 to 1999 Compared to MCL					
Concentration Range (ppb)	Average Concentration (ppb)	Detection Frequency	Screening Value (ppb)	Basis for screening	Above MCL?
ND - 81	18.8	16 / 28	5	EPA's MCL, maximum contaminant level for drinking water	Yes
<i>ND: Non-detected</i>					

The TCE drinking water data indicated that the concentration trended downward from a high of 81 ppb in May 1993 to 29.2 ppb in March 1999. Those data were characterized by alternating periods of elevated TCE levels. These fluctuations are probably due to seasonal variation in groundwater flow, river stage, rainfall and pump rates. However, over time the elevated concentrations decreased [12] as illustrated in Figure 2. This trend occurred in the absence of any remediation and is most likely due to dispersion, degradation, attenuation, and primarily, depletion of source.

Figure 2. Glen Dale Water Works Drinking Water TCE Concentration vs Years



In mid-December 1998, as a removal assessment, a contractor for EPA collected multimedia samples to determine whether the suspected UST and paint gun cleaning station areas were the sources contributing to TCE in the water.

Soil Gas Data

A total of 42 soil gas data points from samples collected in December 1998, from multiple locations and depths on site were reviewed, of which 34 data points were collected at 3 to 4.3 feet bgs, and eight (8) data points from 8 feet bgs. Samples were collected using either a slam bar or the Geoprobe. The highest TCE levels found were at 3 to 4.3 feet bgs near the UST location (6,130 ppbv), the area between the North and South Building on the west of the pump building (10,720 ppbv), and near the former paint cleaning station (348 ppbv). Of the eight (8) soil gas samples taken at 8 feet bgs, TCE was detected near the UST at 137 ppbv, and the highest TCE level, 810 ppbv, was found near the abandoned paint gun cleaning station [5] (Table 4). TCE was not detected in soil gas samples near the municipal well (Well #1). Figures 3 and 4 in Appendix C provide soil gas sample results, sample locations and respective TCE levels [5].

Table 4. TCE Levels in Soil Gas Samples Collected on December 1998

Sample locations	Samples Depth (feet)	Concentration Range (ppbv)	Average Concentration (ppb)	Frequency of Detection
Near the UST west of the North Building	3 to 4	ND – 6,130	1,538	9/14
	8	ND - 137	52.3	1/3
Near the Paint Gun Cleaning station, west of South Building	3 to 4	ND - 348	39	2/14
	8	ND - 810	346	3/5
Between North & South Bldg, west of Pump Bldg	3 to 4	ND – 10,720	5,365	1/2
Near the municipal primary well (Well #1)	8	ND	ND	0/4

ND: Not detected

Soil Data

A total of seven (7) soil borings were completed to depths ranging from 7 to 14 feet bgs at locations where soil gas sample results indicated the potential for soil contamination. A total of 20 soil samples were collected. The highest TCE concentration in soil (980 ppb) was found in the soil sample at 4 feet bgs near the UST location [5]. Figure 5 in Appendix C provides a summary of all available soil sample results and respective TCE levels [5].

Groundwater Data

Based on the soil gas sample results, six (6) temporary wells were installed at depths of 41 feet bgs using the Geoprobe system. The highest TCE concentration of 3,500 ppb was found in a groundwater sample collected between the North and South Buildings near the pump building. TCE was detected at a concentration of 16 ppb in groundwater near municipal water well #1 [5]. Figure 6 in Appendix C provides a summary of all available groundwater sampling locations and respective TCE levels [5].

Exposure Pathway Analysis

WVDHHR’s health consultations are driven by exposure, or contact. One of our major goals is identifying exposure pathways and characterizes the actual exposure situation. For a public health hazard to exist, people must have contact with contaminants at levels high enough and for a long enough time to affect their health.

An exposure pathway is the route by which a contaminant travels from its source to the human body. It consists of five parts:

- a source of contamination
- a media such as water, air or soil through which the contaminant is transported
- a point of exposure, where people can contact the contaminant(s)
- a route of exposure by which the contaminant enters the body, such as ingestion (i.e. drinking or eating), inhalation (i.e. breathing), and dermal absorption (i.e. chemicals get into the body through skin), and
- a receptor population, one or more people who may have contact with the contaminant(s).

A pathway is considered complete if all five elements are present, which means people have been exposed to contaminants. Exposure pathways are considered potential if one or more of the elements are missing or uncertain but could have existed in the past, could be occurring now, or could exist in the future. Exposure pathways are considered eliminated when one or more of these five items do not exist.

Vapor intrusion is the migration of volatile organic chemicals (VOCs) from the subsurface-contaminated groundwater and soil through the pore spaces of soil into above buildings. The vapor within the ground pores is called soil gas. Soil gas can enter residences and other buildings through foundation cracks and gaps, sumps, drains, mechanical ventilation systems, and leakage areas (i.e., utility entry points, construction joints, and drainage systems).

Soil gas monitoring and modeling results can be used to qualify or quantify the indoor air. However, they can only serve as a screening tool to identify conditions warranting additional evaluation; they do not provide actual concentrations of contaminants inhaled by people. Subsurface vapors are greatly diluted by diffusive, advective, or other attenuating mechanisms as the vapor migrate through the soil, and mixing with outdoor air entering the home. Therefore, directly measuring indoor air quality in potentially impacted buildings is the best approach to evaluate air contamination at the point of exposure.

Completed Pathway – Ingestion, Inhalation and Dermal Absorption during Showering

Past exposure to TCE has occurred via the use of contaminated drinking water. Glen Dale Water Works serves approximately 1,100 people, who ingested TCE through drinking water, absorbed TCE through direct skin contact and inhalation during showering and bathing. Assuming that the municipal primary water supply well (Well #1) became contaminated after 1992, the customers of Glen Dale Water Works could have been exposed to up to eight (8) years. Current and future exposure pathways via drinking water supply have been eliminated since the new water treatment plant with an air stripper was brought online in 1999. There are no known users of private well water in the immediate vicinity of the site.

Potential Pathway - Inhalation via Vapor Intrusion

As mentioned above, vapor intrusion is the migration of volatile chemicals from subsurface soil or groundwater into overlying buildings. Vapor intrusion can occur when chemicals in the ground or groundwater move as a gas through the pore spaces of soil and accumulate in buildings where people breathe the air. At this site, no available information has indicated past or current exposure via vapor intrusion has occurred. However, given the persistent nature of TCE in the groundwater, and various complicated factors that could affect the extent of the plume, future exposure via vapor intrusion could be a potential pathway.

The Ohio River is approximately 200 yards west of the site. The typical surface water level of the Ohio River is approximately 40 to 50 feet lower in elevation with respect to the topographic position of the site. Given the close proximity to this major surface water body, it is likely that groundwater approximates the elevation of the Ohio River at the site [13]. Generally, groundwater flows towards a large river. Sometimes, groundwater flow can be redirected toward wells that pump water from the aquifer. The municipal water supply wells were located south of the South Building. In both scenarios at this site, groundwater is expected to flow southwest, the direction away from the facility buildings and the residential neighborhood area located on the east side of the site. This assumption is consistent with the groundwater sampling data from 1998 indicating the groundwater plume extended southward [5]. It appears unlikely that workers at the North and South Buildings and/or residents who lived on the east side of the site were exposed to unsafe TCE levels through vapor intrusion. However, additional data may be necessary to determine if a vapor intrusion investigation is warranted.

Exposure Analysis

Exposure doses are estimates of how much chemical may get into a person's body. The estimate relies on the contaminant levels and assumptions of how much, how often, and how long a person may have contact with a chemical. Exposure doses are expressed as milligrams of contaminant per kilogram of body weight per day (mg/kg/day). Table 5 in Appendix B summarizes the assumptions used in exposure dose estimation. The methodologies used for exposure dose calculations are presented in Appendix A.

Estimated Exposure Doses For Non- Cancer Health Effects

Exposure doses were estimated for three exposed population groups: children 1-6 years old, adolescent (age 7-17 years) and adults. Age-appropriate body weights and the daily water intake rate, the average concentration of TCE in drinking water over the eight years, the protective exposure frequency, and the eight (8) year duration was used for the exposure doses estimation. The overall chronic (over 1 year of exposure) exposure dose was obtained by addition of the exposure dose from ingestion, inhalation and dermal absorption during showering. As indicated in Table 6, the estimated total exposure doses for three (3) exposed population groups exceeded RfD slightly, which does not mean adverse health effects would be expected. However, a further in-depth toxicological evaluation is necessary and is provided as follows.

Table 6. Estimated Chronic Exposure Dose from TCE in Drinking Water							
Exposed Population Group	Estimated Exposure Doses, mg/kg/day				Screening Value (mg/kg/day)	Basis for Screening	Above the Screening Value?
	Ingestion	Inhalation During Showering	Dermal Absorption During Showering	Total Exposure Doses			
Children (age 1-6)	0.00104	0.0000011	0.000004	0.00105	0.0003	EPA RfD	Yes
Adolescents (age 7-17)	0.00063	0.0000016	0.000007	0.00064	0.0003	EPA RfD	Yes
Adults	0.00053	0.0000010	0.000002	0.00054	0.0003	EPA RfD	Yes

An exposure dose via vapor intrusion pathway was not estimated since past and current exposure via this pathway has not been identified.

Non-Cancer Health Effects and Margin of Safety

The EPA's RfD is an estimated amount of a contaminant an individual can be exposed to daily without adverse health effects over a lifetime. The EPA's RfD for TCE is based on the lowest dose where adverse liver effects begin to be observed in two species after sub-chronic dosing (EPA preliminary draft on TCE health risk assessment, 2001). The dose for liver effects is 1 mg/kg/day, and is usually called the Lowest Observed Adverse Effect Level (LOAEL). The RfD for TCE is 0.0003 mg/kg/day, which is obtained by dividing 1 mg/kg/day (the LOAEL) with a composite uncertainty factor of 3,000. This factor takes into account the uncertainties from human variation, applying animal studies to humans, sub-chronic instead of lifetime studies, and the LOAEL instead of the No-Observed-Adverse-Effect-Level (NOAEL). NOAEL is the maximum dose from a study, i.e. a test for the liver effect, at which no adverse health effects are observed. The resultant RfD is actually three thousand times lower than the experimental LOAEL. In other words, it provides a significant margin of safety. For this site, comparing the estimated doses for three exposed population groups with the LOAEL shows that TCE exposure doses at the Glen Dale TCE site are at least 900 times lower than the LOAEL (see Table 7 for margin of safety), and are unlikely to cause adverse, non-cancer health effects.

Table 7. Further Evaluation on Non-Cancer Health Effects

Exposed Population	Total Exposure Doses(mg/kg/day)	Comparison Value (mg/kg/day)	Basis for Comparison Value	Margin of Safety
Children (age 1-6)	0.00105	1.0	EPA's LOAEL For Adverse Liver Effects in Two Species After sub-chronic dosing	952
Adolescents	0.00064			1,562
Adults	0.00054			1,852

Estimated Cancer Risk

The excess cancer risk is the number of cases of cancer in a population that may result from exposure to a particular contaminant at the site under the assumed exposure conditions. A cancer slope factor (CSF) expressed in $(\text{mg/kg/day})^{-1}$, is an upper bound estimate, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to a chemical. The excess cancer risk would be lower if the average response was used to calculate the cancer slope factor. The EPA's provisional CSF for TCE is $0.4 (\text{mg/kg/day})^{-1}$. Many uncertainties and conservative assumptions were applied to determine the CSF such as:

- manipulate the experimental data and extrapolate possible health outcomes from high doses to low doses
- actual exposure doses from human studies are unknown
- assume that there are no thresholds for cancer effects (or low dose linearity)—a single molecule of a carcinogen is assumed to be able to cause cancer

This means the actual risk of cancer is probably lower than the calculated number, perhaps by several orders of magnitude. The true excess cancer risk is unknown and could be as low as zero.

Considering many uncertainties, WVDHHR decided estimated theoretical cancer risks lower than 1 in 10,000 are considered low and need no further review, between 1 and 9.9 in 10,000 are classified as low, between 10 and 99 in 10,000 are classified moderate, and greater than 99 in 10,000 are considered significant.

Estimated cancer risk for exposed population groups was calculated using the overall exposure doses from ingestion, shower inhalation and dermal absorption of shower water. As can be seen in Table 8, the estimated theoretical cancer risk for children age 1-6 is 0.36 in 10,000, for an adolescent is 0.29 in 10,000, and 0.25 in 10,000 for adults. All estimates are below one in 10,000 cancer risk level. For a town the size of Glen Dale with a population less than 1,500, no additional cancer cases would be expected from exposure to the TCE in the drinking water through ingestion, inhalation and dermal absorption.

Table 8. Estimated Cancer Risk From Exposure of TCE in Drinking Water							
Population Groups	Estimated Exposure Doses For Cancer Health Effects, mg/kg/day				EPA's Cancer Slope Factor	Estimated Cancer Risk	Above 1 in 10000 risk Level?
	Ingestion	Inhalation During Showering	Dermal Absorption During Showering	Total Exposure Doses			
Children (age 1-6)	0.000090	0.00000010	0.00000030	0.000090	0.4	0.36 in 10000	No
Adolescent (age 7-17)	0.000072	0.00000019	0.00000077	0.000073	0.4	0.29 in 10000	No
Adult	0.000061	0.00000012	0.00000028	0.000062	0.4	0.25 in 10000	No

The assumptions used in the calculations are listed in the Table 5 Appendix B. The methodology of estimating exposure doses for carcinogenic health effects and excess cancer risk is presented in Appendix A.

Community Health Concerns

Since the TCE contamination in Glen Dale municipal drinking water happened during the past has been resolved since mid-1999, WVDHHR is not aware of any current health concerns being expressed by the community related to TCE site. However, based on information provided by Glen Dale Water Works, community members did express concern on the health impacts of the TCE in the past drinking water. This health consultation was prepared to answer this community health concern. Our assessment indicates there is no apparent public health hazard from past exposures. In addition, current and future exposure has been eliminated through treatment of the public water supply by removing the TCE via air stripping.

Children's Health Considerations

ATSDR/WVDHHR recognizes that infants and children may be more vulnerable to chemical exposure than adults. In evaluating health effects from the site-specific environmental exposures at the site, children were considered as a special population. With regard to chemical exposure, children may have an increased susceptibility due to many factors including:

1. Children weigh less than adults, resulting in higher doses of chemical exposures relative to body weight
2. Children have higher rates of respiration
3. Metabolism and detoxification mechanisms differ in both the very young and very old and may increase or decrease susceptibility, and

4. A child's developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages.

This health consultation considered these factors in the evaluation of potential health effects to children. Children living in the areas receiving drinking water supplied from Glen Dale Water Works are not expected to be at an increased risk of adverse health effects.

Conclusion

The five public health hazard categories used by ATSDR are; no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

The WVDHHR assessed the public health implications of TCE in public drinking water during the past solely based on the available Glen Dale Water Work's drinking water data. Of the exposures evaluated, assumptions regarding contact with observed contamination were generally very conservative (protective). Therefore, actual or potential risks are to be much less. On the other hand, other sources of exposure, such as through consumer products that contained TCE could contribute to an individual's exposure. Those potential contributions are not reflected in the exposure estimates in this report. As with all projections regarding potential exposure and risk, uncertainties exist that could impact conclusions to varying degrees.

Based on the evaluation of available environmental information and data associated with the site, WVDHHR concludes:

1. The eight (8) years of documented TCE exposure (1992-1999) via public drinking water in Glen Dale poses no apparent public health hazard to community members, including children. Non-cancer health effects are not expected. Estimated exposure levels were below levels shown to cause effects in humans and animals.
2. The eight (8) years of documented TCE exposure (1992-1999) via public drinking water in Glen Dale poses no apparent carcinogenic health hazard to community members, including children. WVDHHR estimates theoretical cancer risk from TCE exposure (1992-1999) is less than one additional case of cancer in 10,000 people; which is considered a very low risk. The current cancer rate in the U.S. population is between 30 - 50% i.e., approximately one in three women and one in two men will develop cancer during their lifetime (for additional information go to <http://seer.cancer.gov/statfacts/html/all.html>).
3. It is unlikely workers at the North and South Buildings and/or residents were exposed to unsafe levels (if any) of TCE through vapor intrusion, but a potential still exists (see recommendations as following).

Recommendations

WVDHHR recommends:

1. Continued monitoring of TCE levels, and its break down products, in three existing monitoring wells.
2. Further characterize the nature and extent of the TCE groundwater plume.

3. If necessary, install additional monitoring wells on the east side of the site to ensure that the TCE plume is not impacting residential properties.
4. Determine if a vapor intrusion investigation of the North building is necessary (i.e. additional soil gas samples and/or indoor air sampling).

Public Health Action Plan

1. WVDHHR will provide information to the community, local health officials, and Glen Dale Water Works to assist them with their understanding of the report and the related issues - including a public presentation of this information to the community and city officials.
2. WVDHHR will consider any additional data provided to the agency and revise this health consultation as appropriate. If additional information becomes available or if there are any questions or comments concerning this document, please contact WVDHHR at (304) 558-2981.



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Certification

This Glen Dale TCE Site health consultation was prepared by West Virginia Department of Health and Human Resources (WVDHHR) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and procedures existing at the time the health consultation were initiated. Editorial review was completed by the Cooperative Agreement partner.



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The Division of Health Assessment and Consultation of ATSDR has reviewed this public health consultation and concurred with its findings.



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References

- [1] US Environmental Protection Agency Region III, Administrative Order by Consent for Removal Response Action, In the Matter of: Glen Dale TCE Site, Wheeling Wholesale Grocery Company, Respondent, EPA Docket No. III-99-020-DC
- [2] Weston Solutions, Inc. Sampling Plan, Glen Dale TCE Site, Glen Dale, Marshall County, West Virginia, Prepared for U. S. Environmental Protection Agency Region III, Removal Response Section, Wheeling, WV, 1999 May 28
- [3] Clement F. Sees, Jr., Glen Dale Water Department Public Water Supply ID# 3302605 Distribution System, Marshall County, Office of Environmental Health Services, Environmental Engineering Division, West Virginia Bureau of Public Health Wheeling District, 1997 April 17
- [4] US Environmental Protection Agency Region III, Approval of a Request for Removal Action, Glen Dale TCE Site, Glen Dale, Marshall County, West Virginia, Wheeling, WV 1999 April 26
- [5] John N. Dougherty REAC Task Leader 1999 - Trip Report: Glen Dale TCE Site, Glen Dale, West Virginia, Weston Solutions, Inc.; 1999 April 14, Work Assignment 3-411
- [6] Bureau of the Census. 2000 geographic area: Glen Dale city, West Virginia Available from URL: <http://censtats.census.gov/data/WV/1605431492.pdf>
- [7] West Virginia Department of Education, WV school directory. Available from URL: http://wvde.state.wv.us/ed_directory/index.html?county_id=48&school_id=204
- [8] West Virginia Department of Education, WV school directory. Available from URL: http://wvde.state.wv.us/ed_directory/index.html?county_id=48&school_id=502
- [9] Agency for Toxic Substances and Disease Registry. Texas for Trichloroethylene. Atlanta: US Department of Health and Human Services; 2003. Available from URL: <http://www.atsdr.cdc.gov/tfacts19.html>
- [10] US Environmental Protection Agency Region III, Administrative Order for Removal Response Action, In the Matter of: Glen Dale TCE Superfund Site, EPA Docket No. III-2000-0032-DC
- [11] Free-Col Laboratories, INC, Reliance Analytical Services, Inc. Laboratory Reports, Glen Dale municipal Water Works, West Virginia. Free-Col Laboratories, INC. 1991 July to 1993 May, Reliance Analytical Services, Inc. 1993 August to 2002 March

- [12] John N. Dougherty, REAC Task Leader, Terrence Johnson, REAC Senior Groundwater Modeler, Estimated Soil Clean-up level, Glen Dale TCE Site, Glen Dale, West Virginia, Weston Solutions, Inc.,; 1999 March 23.

- [13] MSES Consultants, Inc. 2005 – Phase 1 Environmental Site Assessment, Rember, LLC Property & Adjacent Property, Glen Dale, West Virginia. 2005 July, Project No. 05-297

- [14] US Environmental Protection Agency. Exposure factors handbook. Washington, DC: US Environmental Protection Agency; 1997 Aug. EPA/600/P-95/002Fa

- [15] US Environmental Protection Agency. Child-Specific Exposure Factors Handbook, Interim Report, Washington, DC: US Environmental Protection Agency; 2002 Sept; EPA-600-P-00-002B

Appendix A: Estimation of Exposure Doses

Exposure Dose Calculation

Both non-cancer and cancer exposure doses are estimated based on different assumed exposure duration. For volatile organic (VOCs) contaminants in water, generally, three exposure pathways will be evaluated: ingestion, inhalation of vapor during hot showering or bathing and the dermal contact during showering or bathing.

Estimate Non-Cancer Exposure Doses

$$ED = \frac{C_w \times IR \times EF}{BW}$$

Where,

ED: Estimated exposure doses, expressed in “mg of contaminant per kg of body weight per day, or mg/kg/day

C_w: Concentration of the contaminant in the environmental media. For this site, the media is water. It is expressed in “mg of contaminant / liter of water”, or ppm

IR: Daily water intake rate (L/day)

EF: Exposure frequency

$$EF = \frac{\text{Actual Exposure Days/Year} \times \text{Exposure Duration (Years)} \times \text{Exposure hours/Day}}{365\text{days /year} \times \text{Exposure Duration (Year)} \times 24\text{hours/day}}$$

BW: Body weight (kilogram)

Exposure via Ingestion

Chronic ingestion exposure doses are calculated based on following exposure inputs and assumptions:

C: Average concentration of the TCE in drinking water, expressed in mg/L

IR: Children (age 1-6): 1.0 L /day [14]

Adolescent: 1.5L /day [14]

Adults: 2.0L /day [14]

EF: A protective exposure frequency of 100% or 1 is used in estimating the doses via ingestion, based on the assumptions that children, adolescents or adults drink water 24 hours /day and 365 days/year for the respective exposure duration.

For example: assuming children's exposure duration is six (6) years,

$$EF = \frac{365 \text{ days/year} \times 6 \text{ years} \times 24 \text{ hours/day}}{365 \text{ days/year} \times 6 \text{ years} \times 24 \text{ hours/day}} = 1$$

BW: Children 1 to 6 years old: 18 kg [14]

Adolescent: 45 kg [14]

Adults: 70 kg [14]

See Table 7 for chronic exposure doses via ingestion

Exposure via Inhalation During Showering

$$ED_{\text{shower-inh-NC}} = \frac{C_{\text{air}} \times IR \times EF_{\text{shower-inh}}}{BW}$$

C_{air} : Concentration of TCE in the bathroom air, expressed in mg/m^3

$$C_{\text{air}} = \frac{C_w \times k \times F_w \times ET_{\text{shower-inh}}}{V_a}$$

Where,

k: Volatilization Factor, based on McKone and on Andelman (ATSDR)

F_w : Shower head water flow rate

$ET_{\text{shower-inh}}$: Exposure time = shower time + time of staying in bathroom immediately after shower

V_a : Air volume in bathroom

Chronic inhalation exposure doses during shower are calculated based on the following inputs and assumptions:

C_w : 0.0188 mg/L (ppm), average concentration of the TCE in drinking water

k: 0.0006

F_w : 8 L water/min

$ET_{\text{shower-inh}}$: Children (age 1-6): 20 minutes [15]

Adolescents: 30 minutes [15]

Adults: 30 minutes [15]

Va: Typical size of 7 x 8 bathroom is 10 m³ which is equivalent to 10,000L

IR: Inhalation rate
Child: 8 m³/day [14]
Adolescent: 13 m³/day [14]
Adult: 13 m³/day [14]

BW: Body weights, using the same body weights as that for exposures via ingestion

EF: Exposure frequency.
Assuming that children take a ten minutes shower or bath, and stay additional ten minutes in the bathroom afterwards each day, 365 days per year up to six years.

$$\begin{aligned} EF_{\text{children-shower-inh-NC}} &= \frac{\text{Actual Exposure Time}}{\text{Total Available Time for Exposure}} \\ &= \frac{365 \text{ days/year} \times 6 \text{ years} \times (20 \text{ minutes} / 60 \text{ minutes}) \text{ hours/day}}{365 \text{ days/year} \times 6 \text{ years} \times 24 \text{ hours/day}} \\ &= 0.014 \end{aligned}$$

Adolescents take a fifteen minutes shower or bath, and stay additional fifteen minutes in the bathroom afterwards each day, 365 days per year up to eight years

$$\begin{aligned} EF_{\text{Adolescents-shower-inh-NC}} &= \frac{\text{Actual Exposure Time}}{\text{Total Available Time for Exposure}} \\ &= \frac{365 \text{ days/year} \times 8 \text{ years} \times (30 \text{ minutes} / 60 \text{ minutes}) \text{ hours/day}}{365 \text{ days/year} \times 8 \text{ years} \times 24 \text{ hours/day}} \\ &= 0.021 \end{aligned}$$

Adults take a ten minutes shower or bath, and stay additional twenty minutes in the bathroom afterwards each day, 365 days per year up to eight years

$$\begin{aligned}
 EF_{\text{Adults-shower-inh-NC}} &= \frac{\text{Actual Exposure Time}}{\text{Total Available Time for Exposure}} \\
 &= \frac{365 \text{ days/year} \times 8 \text{ years} \times (30 \text{ minutes} / 60 \text{ minutes}) \text{ hours/day}}{365 \text{ days/year} \times 8 \text{ years} \times 24 \text{ hours/day}} \\
 &= 0.021
 \end{aligned}$$

See Table 7 for chronic exposure doses via inhalation

Exposure via Dermal Absorption During Showering:

$$ED_{\text{shower dermal}} = \frac{C_{\text{showwater}} \times P \times ET \times SA \times EF_{\text{shower-dermal}}}{BW}$$

Where,

$C_{\text{showwater}}$: Concentration of TCE in the shower water, mg/L

$$\begin{aligned}
 C_{\text{showerwater}} &= C_w \times \% \text{ contaminant remaining in the hot water} \\
 &= C_w \times 40\% \text{ [Ref. EPA Chap.3, risk-based pre. Reme goal,p20]} \\
 &= 0.0188 \text{ mg/L} \times 40\% \\
 &= 0.00752 \text{ mg/L}
 \end{aligned}$$

P: Permeability constant, L/cm².hr

SA: Exposed body surface area, cm²

ET_{shower-dermal}: Exposure time = Duration of shower

BW: Body weight, kg

EF: Exposure frequency

Chronic dermal exposure doses during shower are calculated based on the following inputs and assumptions:

$C_{\text{showwater}}$: 0.00752 mg/L

P: 0.001 L/cm².hr

SA: Children: 7,280 cm² [14]

Adolescent: 15,400 cm² [14]

Adults: 19,400 cm² [14]

ET: Children: 10 min [15]

Adolescents: 15 min [15]

Adults: 10 min [15]

BW: Using the same body weights as that for exposures via ingestion

EF: Exposure frequency.

Assuming that children take a ten minutes shower or bath each day, 365 days per year up to six years.

$$\begin{aligned} EF_{\text{children-shower-dermal-NC}} &= \frac{\text{Actual Exposure Time}}{\text{Total Available Time for Exposure}} \\ &= \frac{365 \text{ days/year} \times 6 \text{ year} \times (10 \text{ minutes}/60 \text{ minutes}) \text{ hours/day}}{365 \text{ days/year} \times 6 \text{ years} \times 24 \text{ hours/day}} \\ &= 0.007 \end{aligned}$$

Adolescents take a 15 minutes shower or bath each day, 365 days per year up to eight years

$$\begin{aligned} EF_{\text{Adolescents-shower-dermal-NC}} &= \frac{\text{Actual Exposure Time}}{\text{Total Available Time for Exposure}} \\ &= \frac{365 \text{ days/year} \times 8 \text{ year} \times (15 \text{ minutes}/60 \text{ minutes}) \text{ hours/day}}{365 \text{ days/year} \times 8 \text{ years} \times 24 \text{ hours/day}} \\ &= 0.010 \end{aligned}$$

Adults take a ten minutes shower or bath each day, 365 days per year up to eight years

$$\begin{aligned} EF_{\text{Adults-shower-dermal-NC}} &= \frac{\text{Actual Exposure Time}}{\text{Total Available Time for Exposure}} \\ &= \frac{365 \text{ days/year} \times 8 \text{ year} \times (10 \text{ minutes}/60 \text{ minutes}) \text{ hours/day}}{365 \text{ days/year} \times 8 \text{ years} \times 24 \text{ hours/day}} \\ &= 0.007 \end{aligned}$$

See Table 7 for chronic exposure doses via dermal absorption

Estimate Carcinogenic Exposure Doses

Exposure dose for carcinogenic health effect is estimated by same method as that of non-cancer except using different exposure frequency (EF), where the actual years of exposure are averaged over the lifetime, generally 70 years.

$$ED_{\text{cancer}} = \frac{C_w \times IR \times EF_{\text{cancer}}}{BW}$$

$$EF_{\text{cancer}} = \frac{\text{Actual exposure time}}{\text{lifetime}}$$

Lifetime: 70 years

Exposure Frequency for Cancer Health Effects

For example:

Exposure dose for cancer health effects via ingestion for each exposed population are estimated using the following exposure frequencies:

$$EF_{\text{children-ing-C}} = \frac{365 \text{ days/year} \times 6 \text{ years} \times 24 \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.086$$

$$EF_{\text{adolescent-ing-C}} = \frac{365 \text{ days/year} \times 8 \text{ years} \times 24 \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.114$$

$$EF_{\text{adult-ing-C}} = \frac{365 \text{ days/year} \times 8 \text{ years} \times 24 \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.114$$

Exposure doses for cancer health effects via inhalation for each exposed population are estimated using the following exposure frequencies:

$$EF_{\text{children-inhal-C}} = \frac{365 \text{ days/year} \times 6 \text{ years} \times (20 \text{ minutes}/60 \text{ minutes}) \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.0012$$

$$EF_{\text{adolescent-inhal-C}} = \frac{365 \text{ days/year} \times 8 \text{ years} \times (30 \text{ minutes}/60 \text{ minutes}) \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.0024$$

$$EF_{\text{adult-inhal-C}} = \frac{365 \text{ days/year} \times 8 \text{ years} \times (30 \text{ minutes}/60 \text{ minutes}) \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.0024$$

Exposure doses for cancer health effects via dermal absorption for each exposed population are estimated using the following exposure frequencies:

$$EF_{\text{children-dermal-C}} = \frac{365 \text{ days/year} \times 6 \text{ years} \times (10 \text{ minutes}/60 \text{ minutes}) \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.0006$$

$$EF_{\text{adolescent-dermal-C}} = \frac{365 \text{ days/year} \times 8 \text{ years} \times (15 \text{ minutes}/60 \text{ minutes}) \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.0012$$

$$EF_{\text{adult-dermal-C}} = \frac{365 \text{ days/year} \times 8 \text{ years} \times (10 \text{ minutes}/60 \text{ minutes}) \text{ hrs/day}}{365 \text{ days/year} \times 70 \text{ years} \times 24 \text{ hrs/day}} = 0.0008$$

See Table 8 for the exposure doses via ingestion, inhalation and dermal absorption for cancer health effects

Estimate Cancer Risk

Cancer Risk = Cancer slope factor x Exposure doses over life time (70 Years)

Appendix B. Tables

Table 2. Glen Dale Municipal Water Works TCE Data

Chemical	Conc.(ppb)	Note	MCL(ppb)	MDL(ppb)	Date Sampled	Date Received	Date tested	Testing lab
TCE	0.25	ND	5	0.5	7/16/1991	unavailable	7/17/1991	Free-col Lab, Inc.
TCE	72		5	0.5	4/15/1992	4/16/1992	4/27/1992	Free-col Lab, Inc.
TCE	59		5	0.5	9/4/1992	9/8/1992	9/16/1992	Free-col Lab, Inc.
TCE	81		5	0.5	5/5/1993	5/7/1992	5/17/1993	Free-col Lab, Inc.
TCE	0.25	ND	5	0.5	8/16/1993	8/17/1993	8/31/1993	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	8/4/1994	8/4/1994	8/15/1994	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	9/8/1994	9/9/1994	9/20/1994	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	1/5/1995	1/6/1995	1/12/1995	Reliance Lab, INC.
TCE	49.9		5	0.5	4/11/1995	4/12/1995	4/13/1995	Reliance Lab, INC.
TCE	22.2		5	0.5	6/21/1995	6/22/1995	6/27/1995	Reliance Lab, INC.
TCE	2.6		5	0.5	9/20/1995	9/21/1995	9/21/1995	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	12/7/1995	12/8/1995	1/8/1996	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	3/20/1996	3/21/1996	5/9/1996	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	5/15/1996	5/16/1996	5/21/1996	Reliance Lab, INC.
TCE	44		5	0.5	7/24/1996	7/25/1996	7/31/1996	Reliance Lab, INC.
TCE	39		5	0.5	8/19/1996	8/20/1996	8/26/1996	Reliance Lab, INC.
TCE	0.25		5	0.5	9/16/1996	9/19/1996	9/30/1996	Reliance Lab, INC.
TCE	2.6		5	0.5	9/26/1996	9/27/1996	10/10/1996	Reliance Lab, INC.
TCE	39		5	0.5	10/22/1996	10/23/1996	10/25/1996	Reliance Lab, INC.
TCE	27		5	0.5	2/20/1997	2/21/1997	3/6/1997	Reliance Lab, INC.
TCE	29		5	0.5	4/1/1997	4/2/1997	4/2/1997	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	5/30/1997	5/30/1997	6/13/1997	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	8/28/1997	8/29/1997	9/3/1997	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	11/3/1997	11/4/1997	11/13/1997	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	2/17/1998	2/18/1998	2/20/1998	Reliance Lab, INC.
TCE	17		5	0.5	5/20/1998	5/21/1998	5/26/1998	Reliance Lab, INC.
TCE	15		5	0.5	8/12/1998	8/13/1998	8/14/1998	Reliance Lab, INC.
TCE	13		5	0.5	11/18/1998	11/19/1998	11/30/1998	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	12/10/1998	12/11/1998	12/15/1998	Reliance Lab, INC.
TCE	29.2		5	0.5	3/5/1999	3/8/1999	3/16/1999	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	5/6/1999	5/7/1999	5/19/1999	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	9/10/1999	9/14/1999	9/16/1999	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	10/21/1999	10/22/1999	11/1/1999	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	10/21/1999	10/22/1999	11/1/1999	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	2/10/2000	2/11/2000	2/16/2000	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	7/19/2000	7/20/2000	7/21/2000	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	3/21/2001	3/22/2001	3/23/2001	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	12/10/2001	12/11/2001	12/20/2001	Reliance Lab, INC.
TCE	0.25	ND	5	0.5	3/18/2002	3/19/2002	3/27/2002	Reliance Lab, INC.

1/2 concentration of the method detection limit(MDL) were used in the places of non-detection(ND)

Table 5. Assumptions for Exposure Dose and Cancer Risk Calculations

Parameter	Definition	Units	Children (1 - 6)	Adolescent (7 - 17)	Adult (>18)	Reference/Source
BW	Body Weight	Kilograms	18	45	70	EPA's Exposure Factors Handbook, August 1997 (EPA 1997), Table 7-3 and 7-11, Mean for each age range
		Pounds	40	99	155	
C_{water}	Avg. TCE concentration in drinking water	mg/L(ppm)	0.0188	0.0188	0.0188	Reference [11]
IR_{water}	Drinking Water Ingestion Rate	Liter/day	1.0	1.5	2.0	EPA 1997, Table 3-30, avg. of mean and 90%
	Actual Days of Exposure Annually	days/year	365	365	365	ATSDR default value
	Actual Exposure Duration	Years	6	8	8	
	Exposure Duration -Carcinogen	yrs	70	70	70	EPA 1997
	Exposure duration-ingestion	hrs/day	24	24	24	ATSDR default value
IR_{air}	Inhalation Rate	m^3/day	8	13	13	EPA 1997, Table 5-23, mean for each age range
$ET_{\text{shower-dermal}}$	Time Spent in Shower	min	10	15	10	EPA 1997, Chapter 15
	Time Spent in Bathroom after Shower	min	10	15	20	
$ET_{\text{shower-inh}}$	Total Time Spent in Bathroom for Each Shower	min	20	30	30	
k	Volatilization Factor Based on McKone and on Andelman	Liter/ m^3	0.60	0.60	0.60	ATSDR public health assessment Guidance Manual, 2005, G7
Fw	Shower Head Water Flow Rate,	Liter/min	8.0	8.0	8.0	ATSDR default value
	Portion of the TCE Remaining in the Shower Water	%	40.0	40.0	40.0	ATSDR default value
Va	Volume of Air, Typical Size of 7 x 8 Bathroom:	m^3	10.0	10.0	10.0	ATSDR default value
		Liter	10,000	10,000	10,000	
p	Permeability Constant	$L/\text{cm}^2 \cdot \text{hr}$	0.001	0.001	0.001	ATSDR default value
SA	Total body Surface Area	cm^2	7,280	15,400	19,400	total body surface area, 50th percentile EPA 1997
CSF	Cancer Slope Factor	$1/(\text{mg}/\text{kg}/\text{day})$	0.4	0.4	0.4	EPA Reg 3 RBC Table

Appendix C: Figures

Figure 1 Glen Dale TCE Site Location Map, Glen Dale, Marshall County, West Virginia



Figure 3. Soil Gas (four feet bgs) Sampling Data and Location (December 1998)

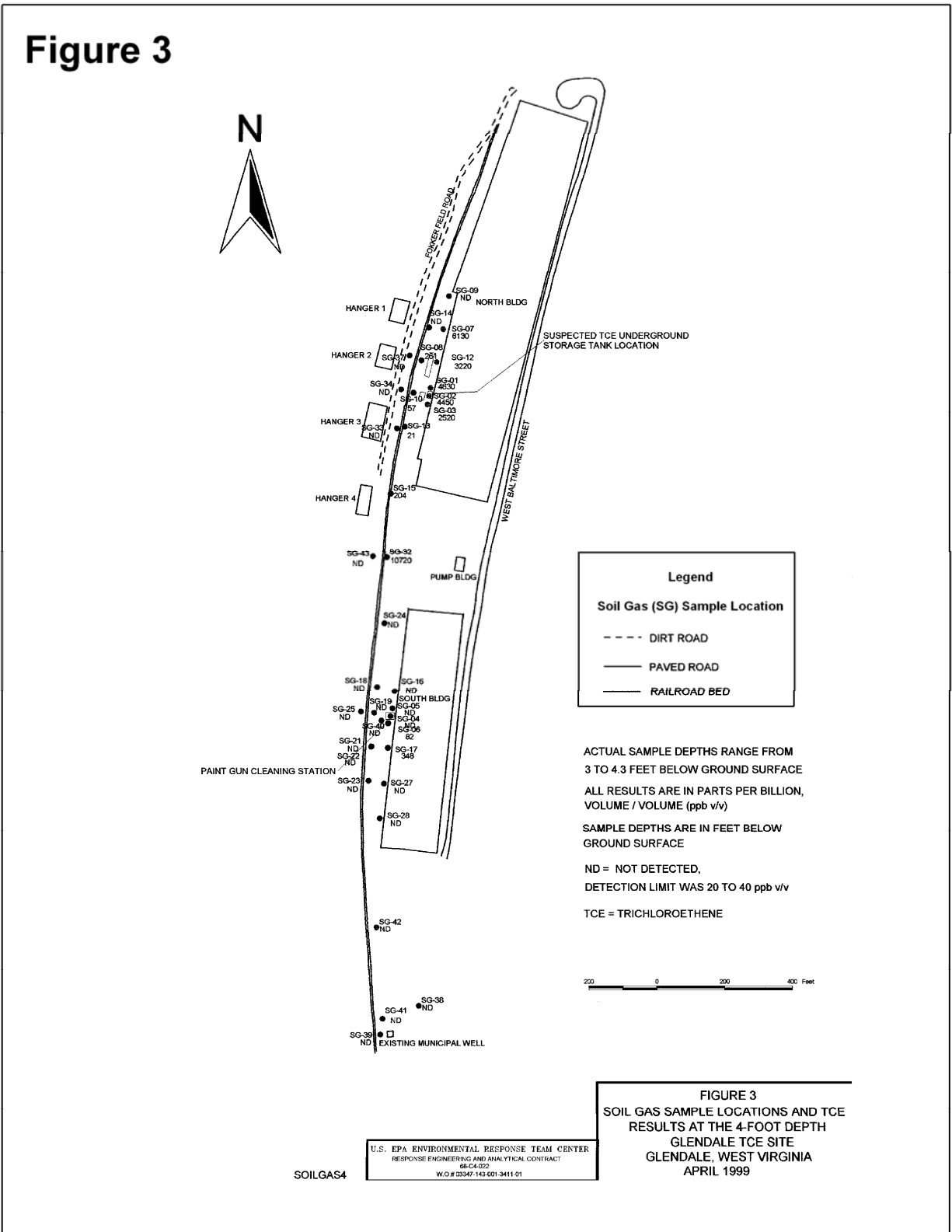


Figure 4. Soil Gas (8 feet bgs) Sampling Location (December 1998)

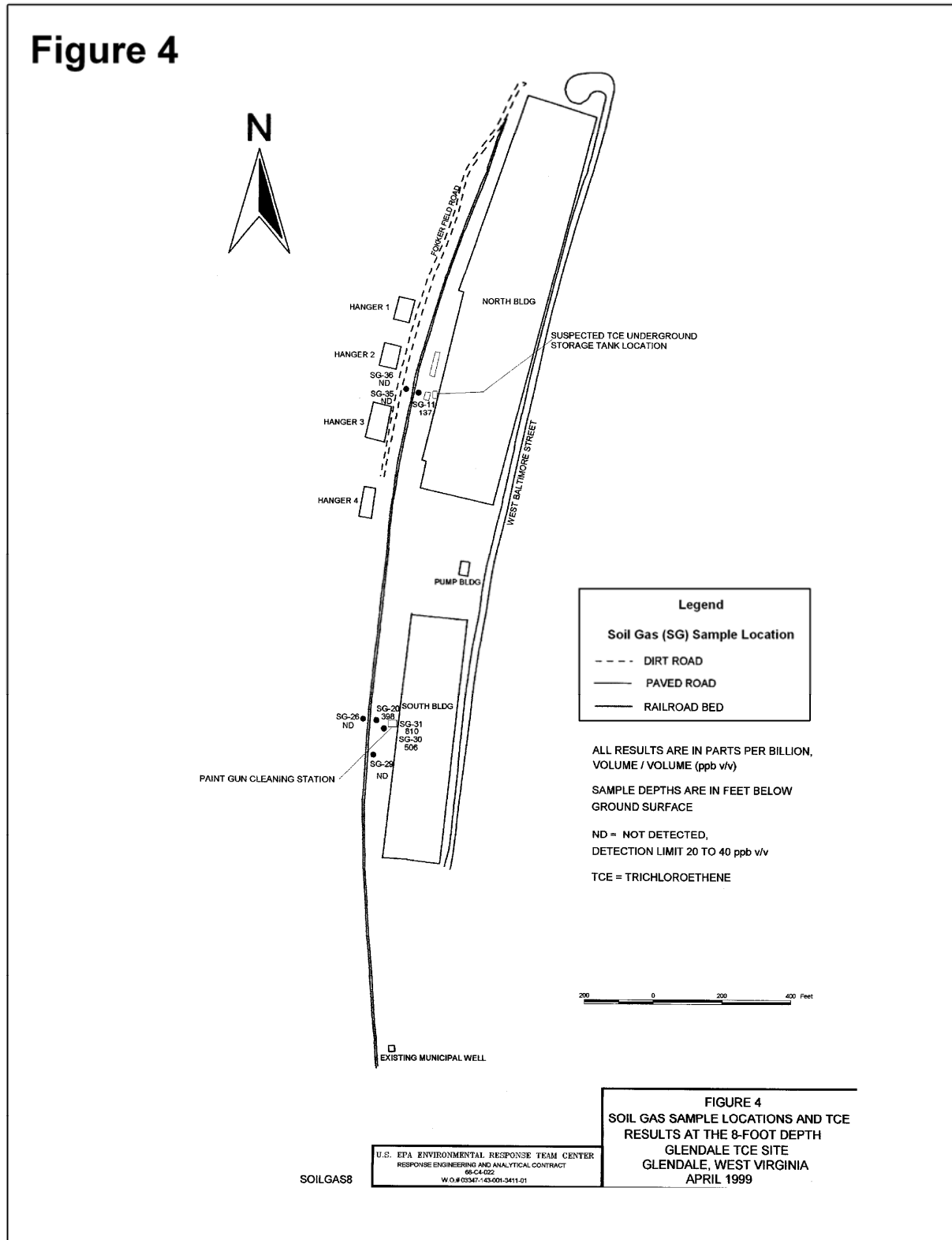


Figure 5. Soil Sampling Data and Location (December 1998)

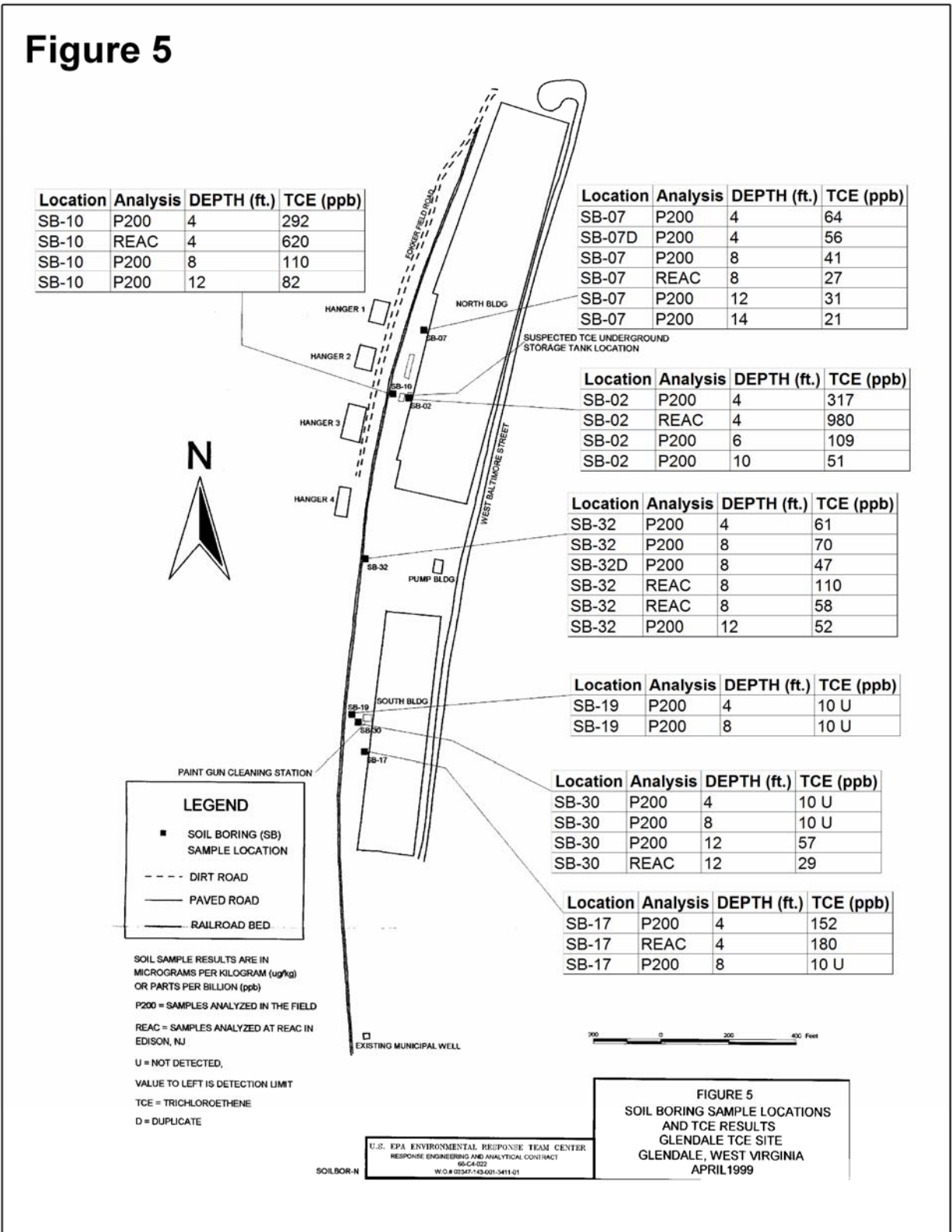


Figure 6. Groundwater Sampling Data and Location (December 1998)

